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RADIOASTRONOMICAL OBSERVATIONS OF VENUS WITH A HIGH RESOLUTION

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RADIOASTRONOMICAL OBSERVATIONS OF VENUS WITH A HIGH RESOLUTION

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ABSTRACT

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Observations with a high resolving capability are closest to hot surface and cold atmosphere model. According to the latter, the temperature of planet's hard surface must be near 600° K, and that of the atmosphere drops sharply to 234° K in the upper layers of the cloud cover. The model assumes also the presence of high pressures (from 20 to 100 atmospheres) near the surface.

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Observations of Venus' radio emission in the 3.02 cm wavelength were conducted in the Main Astronomical Observatory of the USSR Academy of Sciences in October-November 1962. The large Pulkovo

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* RADIOASTRONOMICHESKIYE NABLYUDENIYA VENERY S VYSOKOY RAZRESHAYUSHCHEY SPOSOBNOST'YU.

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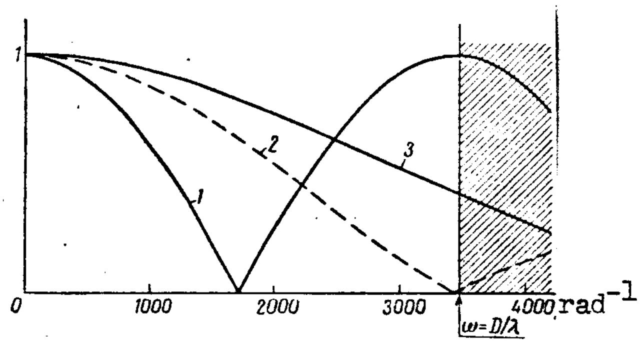
radiotelescope, provided with a variable-profile antenna (VPA), was used to that effect [1]. The measurements aimed at estimating the character of radiobrightness distribution, making use of the high resolving capability of the VPA.



Frequency of the space harmonic (ω)

Fig. 1. Space frequency spectrum of radiobrightness distribution T (x). $1 - T_B = \delta(x - 1'/2) + \delta(x + 1'/2)$; $2 - T_B = 1$ at $x \leqslant 1'/2$, $T_B = 0$ at $x > 1'/2$; $3 - T_B = |1'/2 - x|$ at $x \leqslant 1'/2$, $T_B = 0$ at $x > 1'/2$

The principal possibilities of obtaining informations on the distribution of radiobrightness can be seen from Fig. 1. The curves 1, 2, 3 are space frequency spectra [2] of various radiobrightness distributions for several conceivable models: two point sources at the distance 1', a uniformly bright disk of the same diameter and a disk with linear brightness drop from the center to the edge. Acting as a space frequency filter, the VPA allows the investigation at the 3.02 cm wavelength all the space frequencies through $\omega = D/\lambda = 3500$. The precision in the determination of harmonics' amplitudes is defined by the accuracy of knowledge of antenna filter "frequency characteristic" or antenna radiation pattern and signal to noise ratio. In order to increase the latter, a radiometer with a one-circuit parametric amplifier near 200 mc/s, the noise temperature of the radiometer with the antenna being near 500° K and a sensitivity for antenna temperature near 0.07° with a 1,6 s. time constant, was constructed by the Main Astronomical Observatory of the USSR Academy of Sciences at Pulkovo (GAO A. N.SSSR).

In order to determine with maximum precision the radiotelescope's radiation pattern in the horizontal cross section, the field distribution in antenna aperture was investigated. The phase errors in the aperture were carefully measured with the aid of an invar measuring wire, and eliminated with a precision to $\sim {}^{1}/_{30}\,\lambda$. The amplitude distribution of the irradiation field in the aperture was determined by noise signal generator shifted along the median line of VPA shields. The usual electrodynamic calculation (in our case one-dimensional) allowed to determine the shape of the pattern. Its width by half power level resulted equal to 1'20 ± 0'03 , which practically coincides with the usually admitted value 1.2 /D: the pattern's dimension by the – – 20 db level is 3'1 ± 0!04 .

The observations were conducted in the meridian. The position of the primary radiating element relative to the symmetry plane of the VPA was controlled by geodesy with a precision to ± 0.05 mm , which corresponds to a shift by ± 2 " of the pattern in the sky.

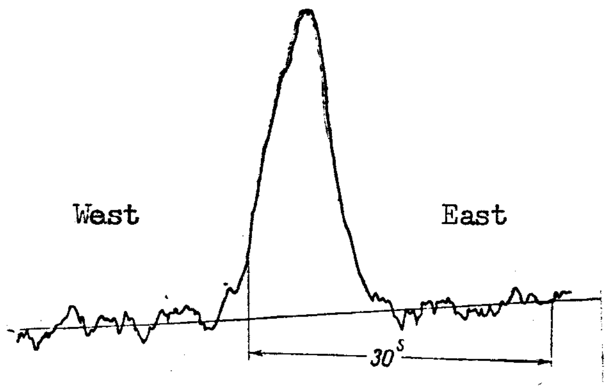


Fig. 2

Sample of Venus passage registration on 16 Dec.1962

A sample of the curve of Venus passing through the radiation pattern is plotted in Fig. 2.

The averaged curve of passage during 15 days near the inner conjunction is shown in Fig. 3. A careful processing of the observations allowed the reaching of the following conclusions.

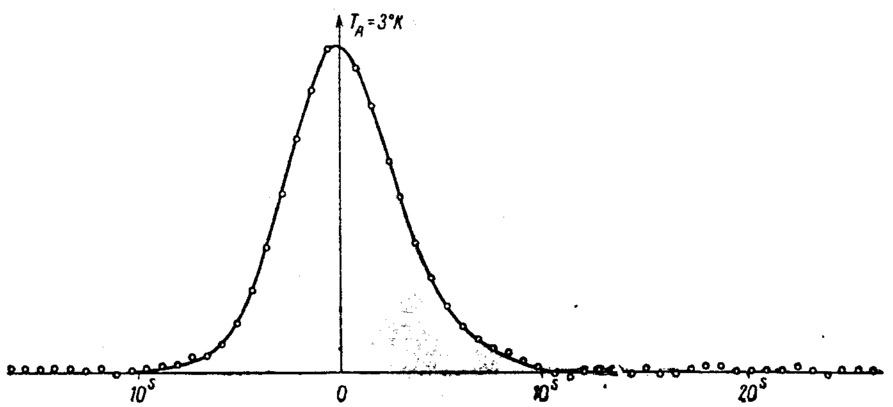


Fig. 3 - Averaged curve of Venus passage. 15-day average.
$\tau = 1.5$. $\lambda = 3.02$ cm

1. The discrepancy between the temperature obtained by optical and radiometrical methods cannot be explained by the presence of powerful radiation belts similarly to what takes place on Jupiter [3]. The radio emission flux from a region of radius $R = 6 R_♀$ does not exceed 3 percent of the radiation flux linked with the visible planet disk. The decrease in the assumed dimension of radiating belts leads to still lower limits.

2. Radio emission is practically absent at the distance of 1.07 $R_♀$ from the center of Planet's disk, i.e. the height of the radio-emitting region does not exceed 420 km above the Venus' cloud cover.

3. The results of measurements of the effective dimensions of Venus are brought out in Fig. 4. Here the values of the parameter σ_i of the Gaussian curve $\exp(-x^2/\sigma_i^2)$, representing the real distribution of radiobrightness in such a way that this Gaussian curve provides the same widening of the radiation pattern as the real brightness distribution. The solid line shows the dependence of the width of the passage curve on σ_i at various assumptions about radiobrightness distribution.

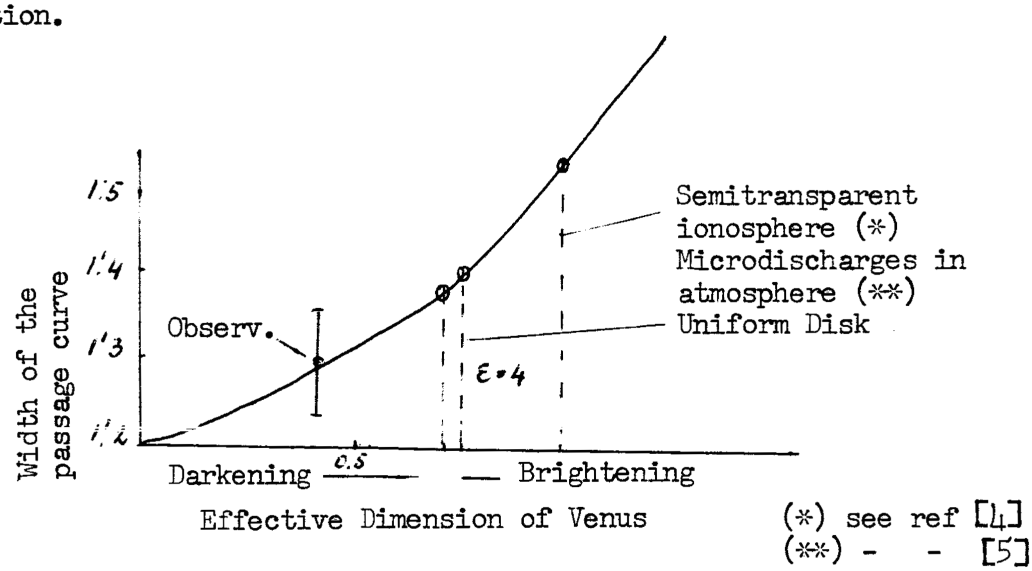


Fig. 4. Results of angle gage measurements of the Dimensions of Venus.

As may be seen from Fig. 4, the observed width of Venus' passage curve obviously does not agree with the hypotheses forecasting brightness increase toward the limb of Planet Venus (semi-transparent ionosphere [4] , hypothses of microdischarges in the atmosphere [5] etc.) The observed width is somewhat less than what follows from the assumption of hard surface emission from the planet with $\varepsilon = 4$. (A still greater discrepancy with a model of isothermic, optically-thick ionosphere or atmosphere, and also hard-surface with $\varepsilon = 1$.) If this difference is real, i.e. if a perceptible darkening takes place toward the limb, it may be explained by the absorption of surface (or near-surface layer) radiation in a cold atmosphere [6 - 8]. However, further observations with a great resolving capability are necessary for a quantitative estimate of this effect. Desirable also are observations of that effect at shorter wavelengths, where it may be stronger.

4. The attempt to determine the phase course of radio temperature by radio emission's center of gravity displacement brought negative results. With a variation from 0 to 0.1 of the share of illuminated surface, the shift of the coordinates of radio emission's center of gravity constituted 0.01 ± 0.13 s. Hence we may conclude that the amplitude of the variable component of Venus' brightness temperature in the 3.02 cm wavelength does not exceed 170° K (estimating at 570° K the mean temperature of the unlit disk). This agrees well with the data by Kuz'min and Salomonovich [9] and definitely does not with the latest data by Lilly [7].

In short, we may state that observations with a high resolution are nearest to hot surface and colad atmosphere model. According to the

the temperature of planet's hard surface is near 600° K, and that of the atmosphere drops sharply to 234° K 9n the upper layers of the cloud cover. The model assumes also the presence of high pressures (from 20 to 100 atmospheres) near the surface.

Planet observations with the aid of radio telescopes of high resolving capability provide a very valuable information on physical conditions on planets. This information is in many cases impossible to obtain while studying planet radio emission. In this case it is necessary to either have recourse to rocket observations, or to ground observations with a substantially lesser resolution (less than 1'). Such resolution is difficult to attain with the aid of usual paraboloids [1]. The precision of the installation and the quality of VPA surface for a subsequent increase of resolving capability in shorter wavelengths is marked for substantial improvement in the Pulkovo Main Observatory of the USSR Academy of Sciences.

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*** THE END ***

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REFERENCES

1. S. E. KHAYKIN, N. L. KAYDANOVSKIY & AL. - Izv.Glavn.Astronom.Observ. 21, v. 5, No.164 3 , 1960.

2. R. N. BRACEWELL, I. A. ROBERTS.- Austr.J. Phys., 7, 615, 1954.

3. THE SOLAR SYSTEM, 3, Ed. G. Kuiper, Univ.of Chicago Press, 442, 1961

4. S. SAGAN, K. SIEGEL, D. JONES, Astronom.J., 66, 2, 52, 1961

5. C. TOLBERT, A. STRAITON., J. Geophys. Res., 67, No 5, 1741, 1961.

6. A. D. KUZ'MIN, A. E. SALOMONOVICH., Astronom.Zhurn. 37, 2, 297, 1960

7. C. SAGAN, Icarus, March 31, 1962.

8. A. BARRET, Astrophys. J., 133, 281, 1961.

9. A. D. KUZ'MIN, A. E. SALOMONOVICH, Astronom. Zh., 38, 1115, 1961.

Main Astronomical Observatory
of the
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